INFRASTRUCTURE QUALITY ASSURANCE UNDER INFORMATION ASYMMETRY

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1. INTRODUCTION

Influence of Deterioration on Our Infrastructure

Deterioration of infrastructure impacts on its quality assurance, and in the future Japan will increasingly be tackling its related cost problems. Since much of the construction and improvement of infrastructure in Japan was completed during its high growth period until the 1970s, most of the structures have aged and the amount of aging infrastructure is continually increasing. According to the Ministry of Land, Infrastructure, Transport and Tourism, it is predicted that the amount of infrastructure that is 50 years old will rapidly increase over the next 15 years, and the percentage of bridges or river management facilities over 50 years old will surpass 60% by 2033. Due to progressive deterioration, old infrastructure may not be able to play an essential role in our society; on the contrary, in the worst case scenario, it is possible that tragic accidents may occur. In fact, in 2012, one of the major road tunnels collapsed because of a lack of maintenance and it resulted in many casualties. Following this accident, four years ago several new quality assurance methods were established. The more the old infrastructure that exists, the more needs to be spent on maintenance and renovation, and we have to provide safe and high quality infrastructure. So, now we are faced with addressing quality assurance of not only aging but also new infrastructure.

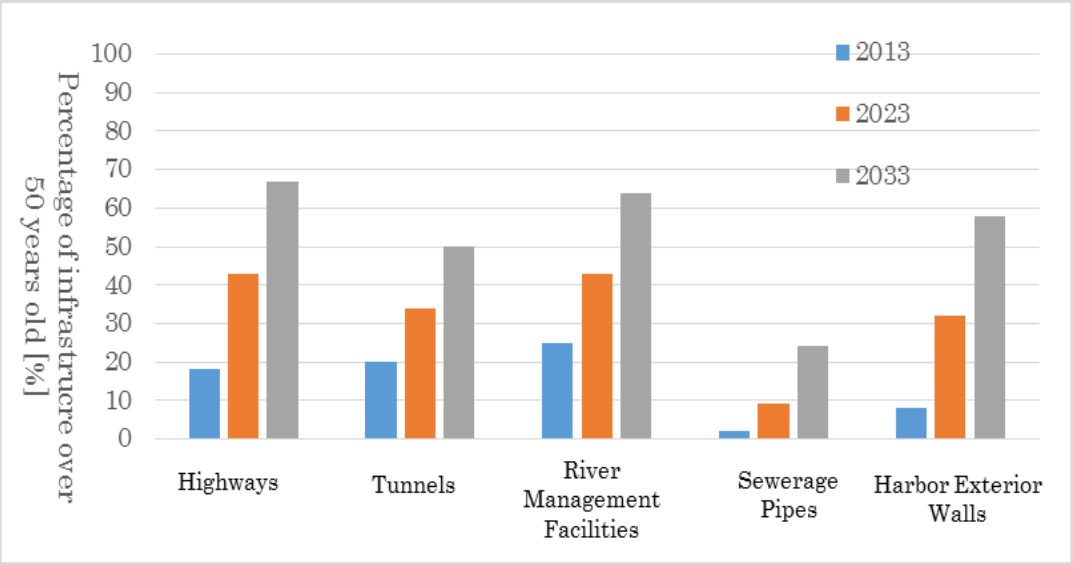

Fig.1 Infrastructure that is over 50 years old

Introduction of the Integrated Evaluation Tender Method and Infrastructure Quality

The integrated evaluation tender method is a bidding method of evaluating prospective construction companies based on bid amount, and in addition such factors as construction period, functions, and safety. In public construction work, this method is introduced to prevent bid-rigging schemes, and inferior quality structures and materials resulting from low cost construction work. Due to its complicated system which takes various factors into consideration, it is expected that the integrated evaluation tender method will eliminate collusion against the antimonopoly law in the future. This method was introduced into most of the ministry's construction work in 2007, and since 2014 the rate of introduction has increased to 70% in the Kanto area.

However, regardless of the implementation of this measure to introduce the integrated evaluation tender method, a bid-rigging case occurred in a bid on a linear motor train project last year. Since we were unable to prevent collusion between the construction companies even after introducing the method, it is necessary to review and modify the contents of the method in order to reliably prevent collusion. In addition, we should strive to improve the transparency of every piece of information regarding public work projects among tenderers on a domestic construction market, and this will lead to quality assurance on all construction projects.

Keywords : Prisoner's dilemma, Moral hazard, Signaling, Screening, a systems of supervision and review
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Purpose

This study offers basic suggestions for improving information asymmetry on public construction work to ensure high quality domestic infrastructure by analyzing behavior analyses of potential bidders. In this study, the author carries out a model behavior analysis based on the game theory. This analysis identifies a situation in which information asymmetry occurs among tenderers in a domestic construction market, and then suggests a solution by comparing differences between a situation in which information asymmetry occurs and a situation in which it doesn't occur. This study can be helpful to improve the quality assurance of infrastructure.

2. METHODS

As part of this study, tenderers' behaviors have been analyzed by means of computer simulations using software called Multi-Agent Simulation. Then, the occurrence of information asymmetry is considered by using trends recognized by the simulation analysis. After considering the analysis, the author offers suggestions for quality assurance.

Multi-Agent Simulation

Multi-Agent Simulation is software provided by Kozo Keikaku Engineering Inc., which enables the user to analyze complex systems such as human experience and social phenomena, to make a model which can make decisions, and to run a simulation on a virtual society. In this study, a virtual construction market is created to analyze tenderers' behaviors. When the model and data are analyzed, a tool called artisoc 4.0 is used.

Information Asymmetry

Information asymmetry is technical jargon in theoretical economics and taken up in the research paper, 'The Market for Lemons: Quality Uncertainty and the Market Mechanism', written by the American theoretical economist, George A. Akerlof. Asymmetric information exists whenever one party to an economic transaction possesses greater material knowledge than the other party. This usually manifests itself when the seller of goods or services has greater knowledge than the buyer, although the opposite is also possible. Almost all economic transactions involve information asymmetries. In the American used car market, it is supposed that an agreement between both parties could be delayed. Moreover, inferior quality used cars could spread in the United States because of information asymmetry.

It is highly probable that information asymmetry also may occur on the construction market as well as the used car market, because the quality of infrastructure construction can deteriorate due to information asymmetry when an agreement is delayed. Therefore, the occurrence of information asymmetry is considered for improvement based on the results of a behavior analysis on a virtual construction market.

3. ANALYSIS

In this simulation, a virtual market model has been created based on the game theory concept of the prisoner's dilemma. Virtual tenderers are judged by their behaviors by means of computer programming, and the trends of tenderers' behaviors are represented in graphs. By analyzing the graphs, the existence of information asymmetry is revealed on the construction market.

Virtual Market Model by Multi-Agent Simulation

A virtual construction market which is as similar to a real market as possible has been simulated on a computer. The number of virtual tenderers is 30 and one behavior out of 30 is chosen during their decision making. The tenderers' behaviors are entered into the computer program in advance and all behaviors are divided into three strategies. One is all cooperation strategy (AllC) as shown as Strategy 1, in which every bidder cooperates to reach an agreement on certain construction projects with other tenderers. Another is all defection strategy (AllD) as shown as Strategy 2, in which every bidder betrays the others and never reaches an agreement. The remaining follow the strategy shown in Strategy 3, in which every bidder continues cooperating with others after having betrayed them once in the past. Each virtual bidder behaves accordingly based on these three strategies. Furthermore, in the case that tenderers cooperate, the simulation shows blue and in the case that tenderers betray, the simulation shows red.

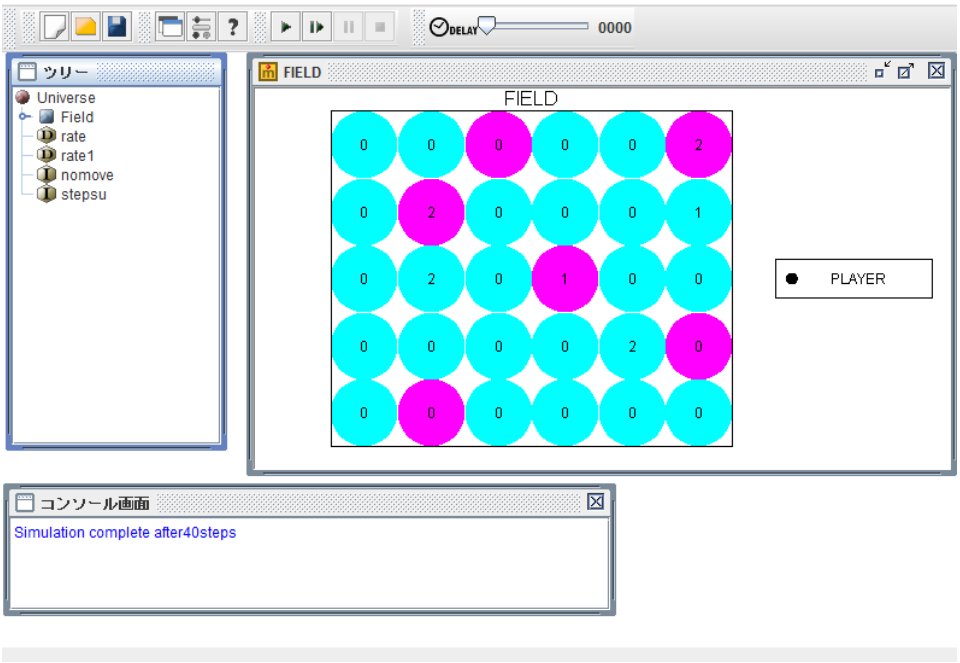

Fig.2 The Simulation Model

The rates in the cases of Strategy 2 and Strategy 3 are set as variable, in order to be able to control by means of a control panel that has been created on the model. The rates in the cases of both Strategy 2 and Strategy 3 range from 0 to 50% and the percentages ranging from 0 to 50% in the case of Strategy2 increase every 5%. Also, the percentages ranging from 0 to 50% in the case of Strategy 3 increase every 10%.

In the graphs, the trends of behaviors are examined focusing on the number of 'steps', which are indicated at the bottom of Figure 2. These steps are counted until all the construction agreements are completed. The longer it takes for a 'step' in the simulation, the less agreements are completed.

The patterns of simulation are divided into 6 patterns subject to Strategy 3. In this simulation, the percentages of Strategy 3 are fixed, but those of Strategy 2 increase every 5% up to 50% in each pattern. Then, all the data and every pattern is examined and the averages of each pattern are calculated.

Results of Analysis

As a result of virtual market analysis, definite differences between cooperating tenderers and non-cooperating tenderers are apparent. It was found that when all tenderers cooperated with other tenderers, the minimum value of steps was represented. This suggests that if tenderers decide to work cooperatively, agreements can be completed in a short period of time. In contrast, as the percentages of non-cooperating tenderers increase, it takes a longer period of time to make a contract. Also, if there was at least one tenderer who never cooperates with others, the contract would not be made smoothly, focusing on the range between 0 and 5%. This trend was seen in all patterns. Therefore, the existence of non- cooperating tenderers may cause information asymmetry on the construction market, and a contract under occurrence of asymmetric information may lead to lower quality infrastructure.

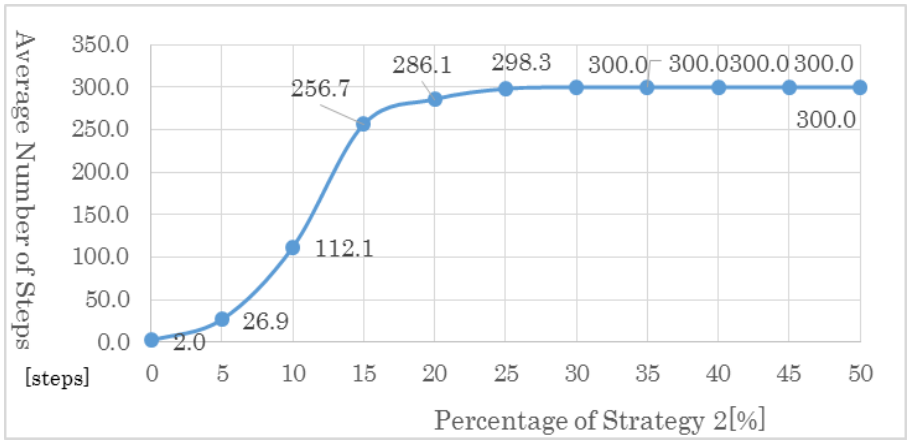

Fig.3 An Example of Analysis Data : Strategy 3=0%

Cooperation and Quality Assurance

Results of this study indicated that cooperation among tenderers is necessary for ensuring infrastructure quality in construction markets, because the existence of non-cooperating tenderers causes the incompletion of contracts and information asymmetry among tenderers. In addition, this phenomenon leads to lower quality infrastructure in public construction work under the occurrence of information asymmetry, because the company that wins a bid on the relevant construction work is not revealed at the time of contract. So, if tenderers regard cooperation with others as a necessary evil, a bid on public construction work is inevitably won by a highly skilled company and quality assurance may be guaranteed by cooperating and taking charge of special areas in this case. However, issues related to the falsification of data are also occurring. Due to this matter, high quality assurance cannot be expected even if highly skilled companies win a bid and it may cause a moral hazard. Therefore, even if tenderers cooperate with other tenderers, other problems relative to infrastructure quality may occur, and it is possible that construction companies cannot necessarily provide the guaranteed infrastructure.

4. CONCLUSION

To improve information asymmetry in construction markets and provide people with assurance of infrastructure quality, tenderers should perform a ‘signaling’ and ‘screening’ of the construction market. For example, in the case of signaling, tenderers should show their advantages compared with other firms. In the case of screening, comprehensive evaluations of the latest construction work performance should be added in the construction field. In addition, a system of supervision and review in the process of the construction work needs to be strengthened regarding every process, as in overseas construction systems. It also needs to ensure the quality of each process, considering that invisible processes exist after the construction is completed. In conclusion, the author suggests that strengthening a system of supervision and review of processes and producing ‘signaling’ and ‘screening’ of the market improves asymmetric information or moral hazard. By producing these systems, the quality of infrastructure can be guaranteed.

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